Science on the Fly!

Loon Migration: Linking People and the Environment

and

The Ecological Impact of Pollution – Conservation Through the Lives of Adirondack Loons

Teacher’s Manual

by

Dr. Nina Schoch
BioDiversity Research Institute’s Adirondack Center for Loon Conservation
OVERVIEW OF BIODIVERSITY RESEARCH INSTITUTE’S ADIRONDACK CENTER FOR LOON CONSERVATION

The mission of BioDiversity Research Institute (BRI) is to assess emerging threats to wildlife and ecosystems through collaborative research, and to use scientific findings to advance environmental awareness and inform decision makers. In 2009, BRI launched its Adirondack Center for Loon Conservation (ACLC) in New York's Adirondack Park, which evolved from the former Adirondack Cooperative Loon Program, a partnership of BRI with the Wildlife Conservation Society (www.wcsadirondacks.org), Natural History Museum of the Adirondacks (www.wildcenter.org), New York State Department of Environmental Conservation (www.dec.state.ny.us), and the Audubon Society of New York (www.auduboninternational.org/programs/asny).

BRI's Adirondack Center for Loon Conservation is dedicated to improving the overall health of the environment, particularly the quality of air and water, through collaborative research and education efforts focusing on loon natural history and conservation issues affecting their populations and aquatic habitats. The ACLC also merges the worlds of field research, public participation, outreach, and education. We seek to minimize anthropogenic impacts on loon populations and other wildlife through a variety of high-quality outreach techniques, including multi-media presentations, newsletters, innovative student curricula, and our website. Adirondack Park residents and visitors are encouraged to learn firsthand about conservation of loons and the environment through participation in our research and monitoring projects. The results of our research efforts are used by wildlife managers and other decision-makers, as well as the public, to ensure that common loons remain an integral and vital part of New York's wildlife heritage, and that their haunting calls continue to echo across Adirondack lakes for generations to come.

WHY STUDY LOONS?

At the top of the aquatic food web, the common loon is an excellent indicator of environmental health, as well as a captivating subject to actively engage students and the public in wildlife conservation, and increase scientific and public understanding of threats impacting aquatic ecosystems in the Northeast. The effect of environmental pollution on wildlife species and their habitats is a growing concern for the long-term viability of wildlife populations and for ecosystems as a whole. Many factors affecting loons and their aquatic habitats are a direct or indirect result of human activity, including environmental pollution, shoreline development, and toxicity due to ingestion of lead fishing tackle. Minimization or elimination of these anthropogenic threats will restore a better balance to loon populations, and lessen the relative impact of natural threats, such as predation, weather, or disease.

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For more information about BRI's Adirondack Center for Loon Conservation, contact:

BRI’s Adirondack Center for Loon Conservation
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888-749-5666 x 145, adkloon@briloon.org
www.briloon.org/science-and-conservation/centers/adirondackloons.php
# TABLE OF CONTENTS

**OVERVIEW OF BIODIVERSITY RESEARCH INSTITUTE’S ADIRONDACK CENTER FOR LOON CONSERVATION** ii

**OVERVIEW OF THE SCIENCE ON THE FLY! CURRICULUM** 1

**ACKNOWLEDGEMENTS** 2

**UNIT #1: LOON MIGRATION – LINKING PEOPLE AND THE ENVIRONMENT** 4

  **WHY SCIENCE INQUIRY? INQUIRING MINDS WANT TO KNOW!** 7

  **CLASSROOM ACTIVITIES** 8

    **INTRODUCTORY ACTIVITY: LOONS UP CLOSE!** 8

    **INTERROGATIVE ACTIVITY: ICE BALLOONS** 10

    **STUDENT DRIVEN - OPEN ENDED INVESTIGATION: POND PLAY** 12

**SCIENCE ON THE FLY! UNIT #1 – LOON MIGRATION TEACHER EVALUATION** 13

**SCIENCE ON THE FLY! UNIT #1 – LOON MIGRATION STUDENT EVALUATION** 15

**UNIT #2: THE ECOLOGICAL IMPACTS OF POLLUTION – CONSERVATION THROUGH THE LIVES OF ADIRONDACK LOONS** 17

**OVERVIEW OF THE MERCURY AND ACID RAIN UNIT OF THE SCIENCE ON THE FLY! WEBSITE** 18

**RESOURCES FOR CLASSROOM ACTIVITIES FOR THE MERCURY AND ACID RAIN UNIT** 19

    **MERCURY POLLUTION** 19

    **ACID DEPOSITION** 20

    **ENERGY CONSERVATION** 22

    **GENERAL ENVIRONMENTAL EDUCATIONAL RESOURCES** 23

**MERCURY AND ACID RAIN UNIT: THE ENVIRONMENTAL SERVICE LEARNING PROJECT** 24

    **SERVICE LEARNING** 24

    **ENVIRONMENTAL SERVICE LEARNING: RECOGNITION** 25

    **STEPS TO CONDUCTING AN ENVIRONMENTAL SERVICE LEARNING PROJECT** 29

    **ENVIRONMENTAL SERVICE LEARNING PROJECT SUMMARY** 31

**SCIENCE ON THE FLY! UNIT #2 – MERCURY AND ACID RAIN TEACHER EVALUATION** 32

**SCIENCE ON THE FLY! UNIT #2 – MERCURY AND ACID RAIN STUDENT EVALUATION** 34

**APPENDIX #1: TEACHER LOG IN TO THE SCIENCE ON THE FLY! WEBSITE** 36

**APPENDIX #2: PHOTOS FOR LOONS UP CLOSE! ACTIVITY** 37

**APPENDIX #3: POND EQUIPMENT MADE EASY** 41

**APPENDIX #4: POND ACTIVITY SAMPLE INQUIRIES AND PROJECT TOPICS** 43

**APPENDIX #5: POND STUDY VOCABULARY LIST AND SUGGESTED WEBSITES** 44

**APPENDIX #6: MERCURY AND ACID RAIN UNIT VOCABULARY LIST** 46

**APPENDIX #7: STUDENT ASSESSMENT RUBRIC** 48

**APPENDIX #8: SCIENCE ON THE FLY! MEETS NEW YORK STATE LEARNING STANDARDS** 49

**APPENDIX #10: LOON MONITORING AND RESEARCH ORGANIZATIONS** 53

**APPENDIX #11: A SAMPLING OF LOON LITERATURE** 55

  **LOON LEGENDS AND CHILDREN’S BOOKS ON LOONS** 55

  **LOON NATURAL HISTORY BOOKS AND LITERATURE** 55

iii
OVERVIEW OF THE **SCIENCE ON THE FLY! CURRICULUM**

The *Science on the Fly!* curriculum consists of two interactive modules:

1. **“Loon Migration: Linking People and the Environment”:** Unit #1 of *Science on the Fly!* is designed for middle school students to teach them about the scientific process and aquatic ecosystems. The charismatic common loon is used as an educational tool to lead students through the steps involved in conducting research and interpreting the results of the data collected. Scientific inquiry learned through the *Loon Migration* module of "*Science on the Fly!*" promotes student centered, open-ended explorations into the dynamics of freshwater aquatic environments.

2. **“The Ecological Impacts of Pollution - Conservation Through the Lives of Adirondack Loons”:** Unit #2 of *Science on the Fly!* is designed for high-school students, the “next generation” responsible for caring for our environment. It builds on the scientific inquiry skills and knowledge that students learned in the “*Loon Migration*” unit to provide them with a comprehensive overview of the environmental impacts of two airborne pollutants: mercury and acid deposition. This unit uses our Adirondack loon mercury research to guide participants through an improved understanding of these significant conservation concerns, including:
   - The chemistry of airborne contaminants, and the interactions of the resulting chemicals in soils and aquatic habitats;
   - The impact of environmental pollution to aquatic ecosystems, wildlife, and humans;
   - Regional, national, and global efforts to decrease airborne pollutants; and
   - Conservation efforts people can do in their own houses and communities.

The Mercury and Acid Rain unit provides a variety of resources for participants to design and implement an Environmental Service Learning Project in the area where they live, thus inspiring students to become actively involved in conservation in their own communities.

**Science on the Fly! Teacher’s Manual and Teachers Training Workshops:**
The *Science on the Fly!* Teacher’s Manual gives an overview of the full curriculum, including information on reference materials and learning standards, as well as supplemental resources. In addition, BRI’s Adirondack Center for Loon Conservation offers a one-day training workshop to teachers in the Adirondack Park of New York State who would like to bring *Science on the Fly!* to their classrooms. Please contact BRI’s Adirondack Center for Loon Conservation to schedule a *Science on the Fly!* workshop in your area of the Adirondack Park.
ACKNOWLEDGEMENTS

Many individuals and organizations contributed to the development and implementation of Loon Migration unit of the Science on the Fly! curriculum. The Environmental Protection Agency’s Environmental Education program, the New York State Biodiversity Research Institute, the Dorr Foundation, and the GE Foundation provided critical funding to the Natural History Museum of the Adirondacks for the development and dissemination of the Loon Migration unit. Additional support for the loon migration research and the Science on the Fly! curriculum was provided by the partnering organizations of the former Adirondack Cooperative Loon Program, including:

- Natural History Museum of the Adirondacks (NHMA) – The Wild Center
- Wildlife Conservation Society (WCS)
- New York State Department of Environmental Conservation (NYS DEC)
- BioDiversity Research Institute (BRI)
- Audubon Society of New York State (ASNY)

We are grateful to Kevin Kenow, of the United States Geological Service’s (USGS) Upper Midwest Environmental Sciences Center for developing the transmitter implantation technique, interpreting the research results, and for providing guidance with transmitter implantation in the Adirondack loons; to Robert Kratt of the USGS for developing the on-line maps; to the US Fish and Wildlife Service for their State Wildlife grant to NYS DEC that funded the transmitters; and to WCS’s veterinary staff for assisting in implanting the birds with the transmitters.

We are especially indebted to Valerie Trudeau, former Education Development Director of the Natural History Museum of the Adirondacks, for her inspirational and enthusiastic vision leading to the development of Science on the Fly! We are also extremely grateful to Tony Charles and the staff of Ad Workshop, Inc. of Lake Placid, including Cindy Short, David Trumpey, Scott MacClanahan, Ben Hamelin, Barbara Muhlenbeck, Dolores Rice, and Jim Duhaime, for their creative and innovative efforts to successfully translate our preliminary ideas into the unique and entertaining Science on the Fly! website, www.ScienceontheFly.org. We also thank A. Hyson and C. Spilman for their contributions to the development of www.ScienceontheFly.org.

The Science on the Fly! video was the brainchild of Crystal Charland, who also stars as the IICI (“Institute for the Insanely Curious Incorporated”) scientist. We thank both Crystal and Rick Godin of Rick Godin Productions for their many long hours of creativity to put together this fun and educational video. The Science on the Fly! video was produced by Rick Godin Productions and the Natural History Museum of the Adirondacks.

We are deeply appreciative to John Timmis of AdirondackNature.com for the many weeks he spent gathering astoundingly beautiful footage of common loons to provide unique insights into the lives of loons through video clips for both the Science on the Fly! website and video. We are also grateful to the many people who participated in the making of the Science on the Fly! video, including:

- David Adams, NYS DEC Bureau of Wildlife
- Adirondack Ecological Center
- Robert Andrews, The Wild Center
- M. Bashant
- Dr. Judith McIntyre, Oikos Foundation
- Fred Realbuto, Audubon Society of New York
- P. Sadowski
- Amy Sauer, ACLP, WCS, and The Wild Center
The Mercury and Acid Rain unit of the Science on the Fly! curriculum was created with the assistance and support of a variety of people and organizations. A. Sauer provided many excellent contributions to this unit of the Science on the Fly! curriculum. Mountain Lake PBS generously supplied video clips from “The Call of the Loon” documentary to include on the website, www.scienceonthefly.org. We are most grateful to R. Godin of Rick Godin Productions for his contributions to the editing of these video clips. We especially would like to recognize the staff at Adworkshop, Inc., in particular, J. Duhaime and B. Hamelin, for their extensive work with developing the Mercury and Acid Rain portion of the website.

The Mercury and Acid Rain unit of the Science on the Fly! curriculum was funded through the generous support of The Dorr Foundation and the New York State Energy Research and Development Authority's Environmental Monitoring, Evaluation, and Protection Program to the Natural History Museum of the Adirondacks and the Wildlife Conservation Society's Adirondack Program respectively.

We would especially like to recognize Mark Watson and Greg Lampman of NYSERDA’s Environmental Monitoring, Evaluation, and Protection Program for their encouragement, logistical support, and funding, through the Wildlife Conservation Society’s Adirondack Program, for the development of the Mercury and Acid Rain unit, which will enable us to inform students about the environmental impact of these critical conservation concerns, and inspire participants to become actively involved in conservation of our world’s unique and limited resources.

Photographs for the Science on the Fly! Teacher’s Manual were provided courtesy of N. Schoch.
UNIT #1: LOON MIGRATION – LINKING PEOPLE AND THE ENVIRONMENT

Welcome to Science on the Fly! Unit #1: Loon Migration: Linking People and the Environment! We are excited to share with you and your middle-school students the results of our research, and new knowledge about common loons summering in New York's six-million acre Adirondack Park.

This first unit of the Science on the Fly! curriculum is designed to complement research on loon migration conducted by the partners of the former Adirondack Cooperative Loon Program. Through this module of the Science on the Fly! curriculum, your middle school students will have the opportunity to learn the process of scientific inquiry as they explore the migration of Adirondack loons and discover new information about wildlife and the environment.

Science on the Fly! employs a variety of intriguing interactive techniques to teach students about science inquiry and the natural world around them. Students can perform their own observations and experiments, as well as observe real scientists in action conducting research on loon migration in New York’s Adirondack Park.

Science on the Fly! can readily be incorporated into middle-school science classes in a variety of subjects because it meets numerous State and Federal Science Education Learning and Teaching Standards. We look forward to working together with you to advance your students’ understanding of the environment and their role in its conservation both locally and globally.

LOON MIGRATION RESEARCH:
In 2003, the partners of the former Adirondack Cooperative Loon Program collaborated with U.S. Geological Survey scientists to initiate a study to answer the question, “Where do Adirondack loons go in the winter?” Satellite telemetry techniques were used to record the southerly migrations of a small number of Adirondack loons, which, until then, had been poorly known. This research contributed greatly to our knowledge of loon natural history by identifying migration routes, staging areas, and wintering grounds important to loons that summer in the Adirondack Park. Our loon migration research provides a scientific basis to focus wildlife and environmental conservation efforts in the Adirondack Park and North America by improving understanding of the human-related and natural risks wildlife species are exposed to throughout their range.

The Loon Migration unit of the Science on the Fly! curriculum introduces middle school students to the process of scientific inquiry using the former Adirondack Cooperative Loon Program’s migration research as an example. This module consists of three components: an instructional video, classroom activities, and the Loon Migration unit of the website, www.scienceonthefly.org. The classroom teacher can utilize the elements individually or integrate them with one another as a full curriculum to teach students about scientific inquiry and the scientific objectives to be fulfilled. The teacher determines the most effective strategy for establishing completion dates and evaluating student progress. Through the Loon Migration unit of the Science on the Fly! curriculum, students also gain an appreciation of the importance of scientific research in the conservation of wildlife and the environment.
1. **Science on the Fly! Video/DVD:**

The *Science on the Fly!* video was created to familiarize and expose students to the steps involved in the scientific process, which provide a foundation for conducting scientific inquiries. The *Science on the Fly!* video enables students to see scientists in action, discussing and conducting research on loon migration, as an example to teach students about the process of scientific research. Students learn how real scientists utilize scientific inquiry to discover new facts about loon habitat utilization throughout the year.

The video can be viewed in its entirety, or alternatively, students can view individual sections of the video corresponding to each step of the scientific process. The class would then discuss a given segment of the video, conduct one of the classroom activities, or proceed through a portion on the *Science on the Fly!* website, www.scienceonthefly.org. For example, the *Ice Balloon* activity could be conducted after viewing the video section on asking questions.

<table>
<thead>
<tr>
<th>SCIENCE ON THE FLY! VIDEO CHAPTERS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Opening</td>
</tr>
<tr>
<td>2. Introduction</td>
</tr>
<tr>
<td>3. Initial Observations and Questions</td>
</tr>
<tr>
<td>4. Research</td>
</tr>
<tr>
<td>5. Form a Hypothesis</td>
</tr>
<tr>
<td>6. Develop a Testing Procedure</td>
</tr>
<tr>
<td>7. Conduct the Test</td>
</tr>
<tr>
<td>8. Organize Your Data</td>
</tr>
<tr>
<td>9. Draw Conclusion</td>
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<tr>
<td>10. Close – The “ICI” Commercial and Science on the Fly! Video Credits</td>
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2. **Students Explore Aquatic Environments Through Classroom Activities:**

The *Science on the Fly!* classroom activities directly involve students in the process of scientific inquiry and reinforce information that the students are learning in the *Science on the Fly!* video and website. Through the *Science on the Fly!* activities, students learn about issues related to biodiversity, particularly in aquatic habitats, and are inspired to develop an interest in wildlife and environmental conservation.

The *Loons Up Close!* activity provides an introduction to loon natural history, and engages students in the initial step of the scientific process of making and recording observations. For classes in the Adirondack Park of New York State, BRI’s Adirondack Center for Loon Conservation can provide an educator to introduce the *Science on the Fly!* curriculum and conduct the *Loons Up Close!* activity.

The *Ice Balloon* activity focuses on the topic of asking questions, an essential element of scientific inquiry. Students obtain an understanding of the value of questioning in science and inquiry, and how to develop a testable hypothesis for scientific investigation.

The *Pond Study* activity is designed to be a long-term project in which students design and implement inquiries about aquatic ecosystems. Students develop questions and hypotheses related to pond communities, design experiments, collect data, analyze results, and interpret and present their conclusions. This long-term study engages students in learning about pond ecology, scientific inquiry, and environmental issues. Through this activity, students increase their understanding of the connections between water quality and its impacts on aquatic communities and wildlife populations.
3. **WEBSITE, WWW.SCIENCEONTHEFLY.ORG:**

The Loon Migration unit of the *Science on the Fly!* website supplements and reinforces the information presented through the *Science on the Fly!* video and classroom activities. The educational objective of the website is to engage students in the use of scientific inquiry while increasing their awareness of wildlife natural history and research, and environmental conservation.

Teachers are able to access [www.scienceonthefly.org](http://www.scienceonthefly.org) separately to review and evaluate each student’s progress through the scientific process (*See Appendix #1 for instructions to log on to the Science on the Fly! website*).

We hope you and your students will enjoy your explorations into the exciting world of scientific research!

*Have Fun, and Happy Learning!*
WHY SCIENCE INQUIRY? INQUIRING MINDS WANT TO KNOW!

Scientific inquiry starts with a true interest in how or why something works, often generated from the student’s own experiences. The topic should be meaningful to the student. It begins with a question, and leads to an investigation of possible answers to that question.

Inquiry is more complex than the scientific method. It is a subtle and challenging exploration that can follow and incorporate the steps of the scientific process. However, inquiry goes far beyond following routine protocols often employed in typical textbook classroom experiments.

The design of an inquiry develops critical thinking skills and may result in a “trial and error” approach that needs time to be tried and tested. Although the traditional school schedule may not always provide time or structure for curiosity to pursue true scientific inquiry, it is important to allot time for collecting information and developing possible hypotheses. Imagination should be encouraged to enable students to build on their background knowledge by exploring different resources and making connections to their previous understanding.

The ability of the student to communicate the results of the inquiry and to construct a meaningful analysis of the data collected is just as important as the data that is collected. Presenting data in imaginative and fun ways encourages creativity and the development of diverse skills in a variety of subjects.

The teacher is essential to successful science inquiry in the classroom. The instructor serves as a mentor or facilitator to a student’s active investigation. The rewards can be immeasurable – the empowerment of the students, and, in return, the true development of student scientists.

Scientific inquiry learned through the Loon Migration unit of the “Science on the Fly!” curriculum promotes student centered, open-ended explorations into aquatic environments. By connecting those investigations to the loon migration research conducted in the Adirondacks, students will gain a better understanding of the links between people, the environment, and its wild inhabitants, such as the common loon.
CLASSROOM ACTIVITIES

INTRODUCTORY ACTIVITY: LOONS UP CLOSE!

OVERVIEW: The natural history of common loons is introduced and explored. Students conduct their own investigations while observing a loon study specimen, decoy, or photos. The unique adaptations and habitat requirements of this species are examined in both the breeding and wintering areas. Students learn the process of recording observations and data in field notes.

SUBJECT: Overview of common loon anatomical features and habitats, and environmental concerns affecting loon populations, introducing students to scientific inquiry and environmental conservation. The importance of accurate record-keeping in scientific research.

SKILLS: Observation, analysis, discussion, and recording of data and observations through field notes and illustrations.

INSTRUCTOR: Teacher or BRI-ACLIC educator (An educator from BRI’s Adirondack Center for Loon Conservation is available to conduct the Loons Up Close activity for schools within New York’s Adirondack Park – mileage reimbursement is requested).

MATERIALS: Drawing paper and pencils for each student, loon mount, decoy, or photos (See Appendix #2).

PREPARATION: If teacher instructs class, he or she should become familiar with the natural history and physical adaptations of common loons (See Appendices #10-#11 for suggested websites and literature for information and resources about loons). Instructor identifies examples of field notes from well-known naturalists, scientists, or artists (e.g.: Charles Darwin, John James Audubon, or Clare Walker Leslie).

ACTIVITY:

1. Instructor directs the students to draw “Gavia immer” without telling the students what it is (the scientific name for common loon). If students are concerned that they do not know what to draw, they are told to draw their best guess as to what they think Gavia immer is.

2. The instructor then unveils a mounted loon specimen, loon decoy, or photographs of loons. Students are directed to draw Gavia immer again, now that they know what it is. In the second drawing, they should also annotate the most striking physical characteristics they observe about common loons.
3. The concept of recording observations and data in field notes and illustrations is introduced. The importance of accurate record keeping in scientific research is discussed. The instructor reviews examples of field notes from historical or current naturalists, artists, and scientists.

4. Educator will ask students what they know about loons and provide a summary of loon characteristics on the chalkboard.

5. The instructor leads a discussion on how the physical characteristics identified in #2 and #4 are important adaptations for loons on their breeding and wintering habitats.

6. Students review loon behavior (e.g., territorial defense, vocalizations) as an example of how wild animals interact with members of their own and other species, as well as how humans influence the normal behavior of loons and other wildlife.

7. Students identify habitat requirements important for loon survival throughout the year. Conservation concerns affecting loon populations and their habitats are identified.

8. Optional activities, such as the “rubber” egg experiment (a whole egg is soaked in vinegar and the results are observed in 1-2 days), could be conducted to demonstrate the ecological impact of pollution and other factors on the environment and its wild inhabitants.

9. Students view the introduction and observation portion of the Science on the Fly! video.
**INTERROGATIVE ACTIVITY: ICE BALLOONS**

**OVERVIEW:** Students connect their experiences with frozen water to their curiosity about a familiar object in a different form. They have the opportunity to explore and link observations to previous knowledge and to test new theories.

**SUBJECT:** Understand the value of questioning in science and inquiry, and how to develop a hypothesis for scientific investigation.

**SKILLS:** Question formulation, investigation, observation, analysis, and discussion.

**INSTRUCTOR:** Teacher

**MATERIALS:**
- Balloons
- Food coloring
- Trays
- 3”x5” index cards
- Poster paper
- Water supply
- Large plastic tubs or aluminum roasting pans (approximately 6” deep x 15” wide x 12” across)
- Salt, sugar, sugar substitute, hammers, ice picks, nails, toothpicks, flashlights, etc... for investigating ice balloons
- Pencils or pens for each person
- Marking pens

**PREPARATION:**
- Students view the initial observation and question portion of the Science on the Fly! video and the website.
- Fill balloons with water. Freeze balloons overnight or longer. It is recommended that each group of 3-4 students has two balloons.

**ACTIVITY:**
1. Students (in small groups of 3-4) generate a number of questions about the ice balloons, as they experiment in an open-ended way on the balloons with any of the available materials. They record their questions on 3”x5” index cards.
2. Each group of students chooses one investigable question and conducts a mini-investigation using the available materials. As they do so, they begin to develop criteria for distinguishing investigable from non-investigable questions.
3. Each group discusses the criteria for recognizing investigable questions by examining their stack of questions generated in Step #2. They record these on a half sheet of poster paper.
4. Students record an example of an investigable question and a non-investigable question on separate sentence strips. The questions are posted for other groups to see.
5. Each group of students shares their criteria, and their investigable and non-investigable questions with the entire class. The group presents one non-investigable question, and what it would take to 'turn' it into an investigable one.

6. The entire class reflects on the process of raising and “turning” questions, the value of criteria for investigable questions, and the role of questioning in the classroom and scientific research.

7. The class discusses how the process of developing questions for investigation relates to hypotheses that are tested in scientific research. The criteria for testable hypotheses are compared to those for investigable questions. The differences and similarities between investigable questions and testable hypotheses are identified.
STUDENT DRIVEN - OPEN ENDED INVESTIGATION: POND PLAY

OVERVIEW: Students learn to examine aquatic ecosystems through observation and experimentation of the ecology of an artificial pond.

SUBJECT: The role of scientific investigation as a method for problem solving.

SKILLS: Question formulation, investigation, observation, analysis, and discussion.

INSTRUCTOR: Teacher

MATERIALS (See Appendix #3):
- 10 gallon or larger aquarium and screened lid
- Aquarium air pump
- Sponge filter
- Plastic aquarium tubing
- Pond water, plants, zooplankton, soil, and aquatic invertebrates and/or vertebrates

PREPARATION: Students view the appropriate portions of the Science on the Fly! video and website as they move through the steps involved in inquiry.

ACTIVITY:
1. Set up the aquarium in the classroom with the assistance of the students. Students identify materials and equipment needed to support aquatic life in the artificial pond habitat.
2. Collect pond material, preferably with the students. If time does not allow, the teacher may prepare the aquatic environment after the students have generated the list of the materials to be included, and the processes needed for a balanced habitat.
3. After the tank has been set up for a few days, the students generate a list of questions relating to the pond tank, reviewing and reinforcing the ice balloon activity. Discuss which questions are investigable.
4. Students self select into small groups according to the questions they generated.
5. Students follow the scientific process to conduct their inquiries:
   1) Research
   2) Hypothesis
   3) Experimental Design
   4) Gathering Materials and Equipment
   5) Conduct the Experiment
   6) Organize the Data
   7) Draw and Present Conclusions
6. Students relate their inquiries about artificial pond habitats to the ecology of actual freshwater habitats in the surrounding area through field trips or independent study projects (see Appendix #4 for suggested inquiries and projects).
SCIENCE ON THE FLY! UNIT #1 – LOON MIGRATION TEACHER EVALUATION

Thank you for participating in the Loon Migration Unit of Science on the Fly! Your feedback is very important to us. We also greatly appreciate receiving copies of your students’ work. If you have examples to send to us, please include them with the evaluation forms.

Teacher: ___________________________ Grade: __________________
School: ___________________________ Date: __________________
Street: ____________________________ Phone: __________________
City, State, Zip: ____________________ E-Mail: __________________

Please place an “A” or “B” in the following categories regarding the applicability of the curriculum components to (A) the interests of the students AND (B) the scientific objectives of the educator:

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<thead>
<tr>
<th>CURRICULUM COMPONENT</th>
<th>POOR</th>
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<td>Classroom Activity – Loons Up Close!</td>
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<td>Classroom Activity – Pond Study</td>
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PLEASE CHECK THE FOLLOWING:

• Teacher’s Manual served as a useful reference.
• Education materials were accompanied with adequate instruction from BRI’s Adirondack Center for Loon Conservation
• Scientific objectives and concepts were clearly outlined and presented in the curriculum.
• Course content was appropriate to age level and learning capabilities of students.
• The Science on the Fly! video/DVD clearly and effectively outlined the steps involved in the scientific process.
• The Science on the Fly! website allowed students to acquire and utilize their knowledge of common loons, Adirondack loon migration research, and the scientific process.
• The classroom activities exposed to students to the ecological links between wildlife, aquatic habitats, and human impacts.
• Curriculum fulfilled appropriate national and state science learning and teaching standards.
• Content and classroom activities build upon previous knowledge base of students.
• Information exposed students to the connections between human activities/impacts and regional environmental conservation issues.
• Presentation of material encouraged students to assess and evaluate the effects of their actions on the environment and its wild inhabitants.
• Curriculum promoted creative thinking and skills to address environmental conservation issues.
Please provide the following comments based on your overall impression of Science on the Fly!:

1. How much do you think your students benefited from the Science on the Fly! curriculum (Circle one)?

<table>
<thead>
<tr>
<th>NOT VERY MUCH</th>
<th>SOME</th>
<th>A GREAT DEAL</th>
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<td>1</td>
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<td>3</td>
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</tbody>
</table>

Please explain:

2. How does the Science on the Fly! curriculum contribute directly to your current curriculum and required course of study (Circle one)?

<table>
<thead>
<tr>
<th>LOOSE FIT</th>
<th>GOOD FIT</th>
<th>INVALUABLE DIRECT FIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
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</tbody>
</table>

Please explain:

3. What did you like best about Science on the Fly!?

4. What did you like least about Science on the Fly!?

5. How could Science on the Fly! be improved?

6. Comments, concerns, ideas...

Please contact BRI’s Adirondack Center for Loon Conservation at 888-749-5666x145 or adkloon@briloon.org with any additional questions or suggestions.

Thank you for your feedback!

Please return form to:

BRI’s Adirondack Center for Loon Conservation
PO Box 195
Ray Brook, NY 12977
**SCIENCE ON THE FLY! UNIT #1 – LOON MIGRATION STUDENT EVALUATION**

The opinions and ideas of the students are very important to us. Teachers, please survey your students by reading aloud the following, and asking the students to record their answers on a sheet of paper that will be submitted to you. Then please tally the student responses and return this evaluation form as a summary of the entire class’s opinions.

**THANK YOU ALL FOR PARTICIPATING IN SCIENCE ON THE FLY!**

Please refer to the following Science on the Fly! curriculum components, and record the number of students that responded in each category:

<table>
<thead>
<tr>
<th>CURRICULUM COMPONENT</th>
<th>POOR</th>
<th>FAIR</th>
<th>GOOD</th>
<th>GREAT</th>
<th>EXCELLENT!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science on the Fly! Video/DVD</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Science on the Fly! Website</td>
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<tr>
<td>Classroom Activity – Loons Up Close!</td>
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<tr>
<td>Classroom Activity – Ice Balloons</td>
<td></td>
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<tr>
<td>Classroom Activity – Pond Study</td>
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<td></td>
</tr>
</tbody>
</table>

Please ask your students to choose which component of the Science on the Fly! curriculum they found most enjoyable and why. Record the number of students that responded in each category.

<table>
<thead>
<tr>
<th>CURRICULUM COMPONENT</th>
<th>LEAST ENJOYABLE</th>
<th>MOST ENJOYABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science on the Fly! Video/DVD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science on the Fly! Website</td>
<td></td>
<td></td>
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<tr>
<td>Classroom Activity – Loons Up Close!</td>
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<tr>
<td>Classroom Activity – Ice Balloons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classroom Activity – Pond Study</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please provide 2-3 comments from your students about the aspects of the Science on the Fly! curriculum components they enjoyed or did not enjoy:

**SCIENCE ON THE FLY! VIDEO/DVD:**

Students enjoyed:

Students did not enjoy:

**SCIENCE ON THE FLY! WEBSITE:**

Students enjoyed:

Students did not enjoy:

**CLASSROOM ACTIVITY – LOONS UP CLOSE!**

Students enjoyed:

Students did not enjoy:
**CLASSROOM ACTIVITY – ICE BALLOONS:**
Students enjoyed:

Students did not enjoy:

**CLASSROOM ACTIVITY – POND STUDY:**
Students enjoyed:

Students did not enjoy:

*Please read the following to your students, and provide comments from the students regarding their overall opinion of Science on the Fly!:

1. Was there anything the students would like to see or do that was not in the curriculum? Please explain:

2. How much of Science on the Fly! was new material for the students *(Please record the number of students in each category)*?

<table>
<thead>
<tr>
<th>IT WAS A REVIEW</th>
<th>SOME WAS NEW</th>
<th>IT WAS ALL NEW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 =</td>
<td>2 =</td>
<td>3 =</td>
</tr>
<tr>
<td>4 =</td>
<td>5 =</td>
<td></td>
</tr>
</tbody>
</table>

3. How interesting was Science on the Fly! to the students *(Please record the number of students in each category)*?

<table>
<thead>
<tr>
<th>BORING</th>
<th>SOMEWHAT INTERESTING</th>
<th>VERY INTERESTING</th>
</tr>
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<tbody>
<tr>
<td>1 =</td>
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<tr>
<td>4 =</td>
<td>5 =</td>
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</tbody>
</table>

4. What were three of the most interesting things the students learned?
   a.
   b.
   c.

5. Was there anything that was confusing or unclear in the program? Please explain:

6. Please include any additional student comments below or on the back of this page.

*Thank you for your suggestions!*

**Teachers, please return form to:**

BRI’s Adirondack Center for Loon Conservation
PO Box 195
Ray Brook, NY 12977
UNIT #2: THE ECOLOGICAL IMPACTS OF POLLUTION – CONSERVATION THROUGH THE LIVES OF ADIRONDACK LOONS

This interactive unit of Science on the Fly! is designed for high-school students, the “next generation” responsible for caring for our environment. It builds on the scientific inquiry skills and knowledge that students learned in Unit #1, “Loon Migration – Linking People and the Environment,” to provide them with a comprehensive overview of the environmental impacts of two airborne pollutants: mercury and acid deposition. The “Mercury and Acid Rain” unit uses the Adirondack loon mercury research of BRI and its collaborators as a basis to guide participants through an improved understanding of these significant conservation concerns, including:

- The chemistry of airborne contaminants, and the interactions of the resulting chemicals in soils and aquatic habitats;
- The impact of environmental pollution to aquatic ecosystems, wildlife, and humans;
- Regional, national, and global efforts to decrease airborne pollutants; and
- Conservation efforts people can do in their own houses and communities.

The Mercury and Acid Rain unit of the Science on the Fly! curriculum consists of three separate elements, which can be utilized individually or as a full curriculum for high-school students to educate them about, and inspire them to become involved in, environmental conservation. The components include:

1. **The interactive Science on the Fly! website, www.scienceonthefly.org**, which provides students with a broad overview of:
   a. The sources of the airborne pollutants, mercury and acid deposition,
   b. The chemistry of mercury and acidic pollutants in aquatic and terrestrial ecosystems,
   c. The impact of these environmental contaminants to terrestrial and aquatic habitats, wildlife, and humans,
   d. How scientists in New York’s Adirondack Park research the impact of mercury pollution on common loons,
   e. State, regional, national, and global efforts to reduce mercury and acidic pollution,
   f. Energy conservation ideas for their own homes and in their local communities, and
   g. Developing and implementing Environmental Service Learning Projects.

2. **Resources for classroom activities** to actively engage students in learning about:
   a. Mercury pollution and its ecological impacts
   b. Acid deposition and its environmental and biological effects
   c. Energy conservation

3. **Conducting an Environmental Service Learning Project.** Students, under the guidance of their teachers or other mentors, design and implement their own Environmental Service Learning Project (ESLP). A variety of resources are provided in the website and the Teacher’s Manual for participants to design and implement an ESLP in the area where they live, thus enabling students to become directly involved in conservation in their own communities.
OVERVIEW OF THE MERCURY AND ACID RAIN UNIT OF THE
SCIENCE ON THE FLY! WEBSITE

The objectives of the Mercury and Acid Rain unit of the Science on the Fly! website, www.scienceonthefly.org, are to:

1. Increase student understanding of the critical ecological concern of airborne pollutants, in particular mercury and acid deposition, and their impacts to terrestrial and aquatic ecosystems.

2. Introduce students to actively participating in environmental conservation in their own home and in their local communities through an Environmental Service Learning Project.

Through the website, students review the chemistry of mercury and acidic pollutants, the anthropogenic sources of these environmental contaminants, and their impacts to terrestrial and aquatic ecosystems, wildlife, and humans. They will learn how scientists in New York’s Adirondack Park utilize the common loon as a biotic indicator of environmental mercury contamination and conduct research to determine mercury’s impact on loon reproductive success. Students are provided with resources and links to further investigate these issues, and to learn about state, regional, national, and global efforts to reduce environmental pollution.

The website provides a variety of resources for students to learn about conducting energy conservation at the local level in their homes, schools, and communities. Additionally, students are introduced to the concept of designing and implementing an Environmental Service Learning Project to enable them to directly participate in conservation in their own communities.

Students record their answers to questions about the topics and their ideas in their Science on the Fly! website notebook, enabling educators to evaluate their new knowledge. Students’ ideas can be reviewed individually or through class discussions.
RESOURCES FOR CLASSROOM ACTIVITIES FOR THE MERCURY AND ACID RAIN UNIT

Numerous curricula and activities exist to teach students about acid deposition, mercury pollution, and energy conservation. Below are listed a variety of resources, some free and some with a charge, that educators will find useful to accompany the Mercury and Acid Rain unit of the Science on the Fly! curriculum. Note that this list is not comprehensive, as new resources are constantly available, nor is it an endorsement of any specific project or organization.

MERCURY POLLUTION:

- **Lesson Planet – Mercury Lesson Plans**
  - [www.lessonplanet.com/search?media=lesson&keywords=mercury+pollution&grade=Select+Grade&rating=3](www.lessonplanet.com/search?media=lesson&keywords=mercury+pollution&grade=Select+Grade&rating=3)
  - A variety of teacher-reviewed middle and high school lesson plans on mercury pollution and its environmental impacts. Lesson plans for all grades on numerous subjects also available.
  - $39.95/year subscription to utilize all lesson plans and worksheets for all subjects.

- **Mercury (the element) in Our Environment: Problems and Solutions**
  - [www.cetonline.org/Schools/Hgcurriculum.pdf](www.cetonline.org/Schools/Hgcurriculum.pdf)
  - CET developed a curriculum to guide teachers from 4th to 8th grade in ways to introduce the problem of environmental mercury to their students. The curriculum: offers interactive, hands-on activities, assignments, and follow-up activities for students at a variety of levels. Links are provided to the Massachusetts Dept. of Education Curriculum Frameworks.

- **Mercury in Schools**
  - [www.mercuryinschools.uwex.edu/curriculum/index.htm](www.mercuryinschools.uwex.edu/curriculum/index.htm)
  - The curriculum provides a national focus on issue of mercury. It includes information and activities on health issues, cultural uses, mercury in schools, mercury at home, mercury in the community, environmental impacts and the history of mercury use. Activities include a Mercury I.Q. Test, Mercury in the Food Chain, Mercury in the Atmosphere, and Mercury through the Ages. Correlations to national education standards for science, social studies and health are provided.

- **Teach About Mercury – 6 Complete Science Units**
  - The program is designed to use scientific research conducted at Acadia National Park as the foundation for citizen science programs in schools. The curriculum is designed to engage students not only in data collection and field work, but to also engage them in higher level science learning that includes inquiry and using data to answer questions. An equally important design goal is to engage students and teachers more closely in the work and stewardship of Acadia National Park.
U.S. EPA: Mercury: In Your Community and the Environment
- www.epa.gov/glnpo/bnsdocs/merccomm/merccomm.pdf
- This guide contains background materials on mercury for teachers, and activities for high school students to educate them about how mercury affects health and the environment, how to find mercury in their school and homes, and provides information enabling school officials and family members to do something about mercury in schools and households.

ACID DEPOSITION:
- Acid Rain Research: An Access Excellence Inquiry Lab
  - Students identify areas of study regarding acid rain to research; design an experiment and identify relevant variables to measure; and collect data using equipment they have designed and constructed. The data is exchanged with other classes and schools via telecommunication, including electronic discussion groups.

- Hubbard Brook Research Foundation – Exploring Acid Rain
  - www.hubbardbrookfoundation.org/education_outreach/
  - This curriculum is designed to teach secondary students about the ecological impacts of acid deposition through classroom activities and outdoor fieldwork. Aligned with the New Hampshire Science Frameworks, the guide provides slideshows, lessons, fieldwork protocols for measuring acid rain parameters, and ideas for student research projects.

- Inside Rain: Working with Precipitation Chemistry Data; Grades 9-12
  - The Inside Rain curriculum includes the Database Basics manual containing three units, Creating Databases; Working With Data Sets; and Making Decisions Based On Data, as well as Inside Rain activities. Data and deposition maps from the National Atmospheric Deposition Program, (http://nadp.sws.uiuc.edu) including the National Trends Network, the Atmospheric Integrated Research Monitoring Network, and the Mercury Deposition Network, is utilized in the activities to teach participants valuable data analysis techniques, providing a foundation for more complex work. Activities contain a student section, teacher section, materials and equipment lists, questions and answers, and permissions to reproduce for classroom use and workshop instruction.
  - Cost = $44.95

- In the Air curriculum, Grades K-12
  - www.intheair.org
  - Comprehensive educational materials about airborne pollutants and making connections between human behavior and air quality.

- Lesson Planet – Acid Rain Lesson Plans
  - www.lessonplanet.com/search/Science/Environment/Acid_Rain
  - A variety of teacher-reviewed middle and high school lesson plans and worksheets/activities on acid rain, its sources, chemistry, and environmental impacts. Lesson plans for all grades on numerous subjects also available.
  - $39.95/year subscription to utilize all lesson plans and worksheets for all subjects.
- **Planet Diary – Acid Rain Activity**
  - [www.planetdiary.com/background/atmoacti.html](http://www.planetdiary.com/background/atmoacti.html)
  - Question and Answer acid rain activity that reinforces concepts taught in the Mercury and Acid Rain Unit of [www.scienceonthefly.org](http://www.scienceonthefly.org).

- **Science Across the World – Acid Rain**
  - [www.scienceacross.org/index.cfm?fuseaction=content.showcontent&node=101](http://www.scienceacross.org/index.cfm?fuseaction=content.showcontent&node=101)
  - Participation in the acid rain topic of *Science Across the World* provides students with an improved understanding of acid rain as an issue in science and technology, and its environmental and societal effects. By exchanging ideas and research findings with other schools throughout the world, students will obtain a global perspective on the impact of acid rain, and will develop key communication, ICT, collaborative, problem solving, reasoning, inquiry, creative thinking, and evaluation skills.
  - *Science Across the World* also provides a wide range of other topics concerning diet and health, the environment, and energy use, in addition to free resources in several languages. The topics and resources are designed for students aged 10-16 years. Teachers can link science with other curricular activities, including citizenship and sustainable development education.

- **U.S. EPA: Educational Resources Exploring Acid Rain**
  - [www.epa.gov/acidrain/education/index.html](http://www.epa.gov/acidrain/education/index.html)
  - [www.epa.gov/acidrain/education/learning.html](http://www.epa.gov/acidrain/education/learning.html)
  - [www.epa.gov/acidrain/education/experiments.html](http://www.epa.gov/acidrain/education/experiments.html)
  - This site gives students first-hand experience about the potential environmental and health effects of acid rain through a wide variety of acid rain-related learning activities and science experiments.

  - **Learning About Acid Rain - A Teacher's Guide for Grades 6 through 8**
    - [www.epa.gov/acidrain/education/teachersguide.pdf](http://www.epa.gov/acidrain/education/teachersguide.pdf)
    - The *Learning About Acid Rain* Teacher's Guide provides activities and experiments to teach students about the science of acid rain, its causes and effects, and regulatory and citizen actions to address acid rain.

- **U.S. National Park Service - Acid rain curricula for grades 6-8**
  - [www.nature.nps.gov/air/edu/Lessons/AcidRLessonPlan.cfm](http://www.nature.nps.gov/air/edu/Lessons/AcidRLessonPlan.cfm)
  - An Acid Rain Lesson Plan for grades 6-8 to teach students about acid rain.

  - [www.nature.nps.gov/air/edu/docs/Curriculum_Info_Guide.pdf](http://www.nature.nps.gov/air/edu/docs/Curriculum_Info_Guide.pdf)
  - Air quality curriculum, lesson plans, and resource guides for educators.
ENERGY CONSERVATION:

➢ **The Energy Conservation Curriculum**
  - Navarro College, P.O. Box 1170, Corsicana, TX 75110
  - The 11 module Energy Conservation Curriculum is a practical, hands-on vocational program that enables secondary, postsecondary, or adult students to identify, monitor, manage, and curb energy usage in their daily lives and living habits. Topics include: awareness of the energy dilemma; energy usage; understanding utility bills; energy conservation opportunities for water, lighting, and appliances; energy consumption as related to building construction; human comfort and energy; heating, ventilating, and air conditioning conservation opportunities; and the economics of energy conservation. An extensive bibliography of audiovisuals, books, games, government documents, journals and periodicals, and reports is also included in Module 12.
  - $25.00

➢ Energy Conservation Resources for Teachers
  - A useful list of energy conservation resources for teachers which provides websites for the resources, costs, and alignment with education standards.

➢ The National Energy Education and Development Project (NEED)
  - [www.need.org](http://www.need.org)
  - The NEED project educates participants about conventional and emerging energy sources; energy consumption, efficiency, and conservation; and the impact of different energy sources to the environment, economy, and society. Tools are also provided to enable educators, energy managers, and consumers to use energy efficiently. NEED curriculum materials meet, align, and exceed the National Science Education Content Standards and state standards. In addition to engaging curriculum materials, NEED also provides professional development, turnkey assessment and evaluation tools, and high quality teacher support. The energy-related accomplishments of educators and students participating in NEED are recognized through the Youth Awards Program for Energy Achievement.

➢ New York State Energy Research and Development Authority’s Energy Smart Students Program
  - This program offers curricula and hands-on applications-based instructional support for classroom lessons in energy, its environmental impacts, and energy efficiency. Workshops are provided to increase educators’ ability to promote energy conservation understanding and action among their students.
  - NYSERDA’s Energy Smart resources and curriculum materials for teachers, including fact sheets and activities to inspire energy conservation in students’ homes.
Watt Watchers of Texas
- www.wattwatchers.org
- Student patrols look for lights left on in empty classrooms and get involved in other projects to stop energy waste, save money, and prevent pollution in their schools. Workshops, kits, and other resources are also available.
- http://wattwatchers.org/pages/kisp.htm
- Knowledge is Power is an energy efficiency curriculum supplement developed by Watt Watchers for grades K-12. Energy conservation and efficiency lesson plans include starter activities, extensions and discussion questions, and cover such subjects as math, science, social studies, and language arts. The lessons are correlated to the Texas Essential Knowledge and Skills.

General Environmental Educational Resources:
- Environment Canada – Free Educational Resources for Educators
  - www.ec.gc.ca/education/default.asp?lang=En&n=D3D10112-1
  - Lesson plans and teachers guides for students of all ages about a variety of environmental subjects.
- Newton’s Apple: Teacher’s Guides
  - www.newtonsapple.tv/TeacherGuides_alphabet.php
  - A variety of lessons and activities, from acid rain to zoo veterinarians, for science educators to teach about the environment, science, and conservation concerns.
- Project Wet
  - www.projectwet.org
  - Project Wet provides resources, training workshops, community water-related events, and a network of educators, water-resource professionals and scientists regarding water quality, conservation/sustainability, and personal responsibility for maintaining water resources.
- Project Wild
  - www.projectwild.org
  - A conservation and environmental education program for K-12 students and their educators, focused on wildlife. As well as providing information, Project WILD helps students learn how to evaluate choices and make responsible decisions regarding wildlife and the environment.
- Texas Commission on Environmental Quality - Environmental Educator Resources
  - www.tceq.state.tx.us/assistance/education/k-12education/K12education.html
  - An extensive list of resources and educational activities for environmental educators, with a focus on Texas.
**MERCURY AND ACID RAIN UNIT: THE ENVIRONMENTAL SERVICE LEARNING PROJECT**

Service learning is a type of experiential learning that actively engages students in community service as part of their academic curriculum. In environmental service learning, participants conduct community service that will protect, maintain, or enhance the environment.

As part of the Mercury and Acid Rain Unit of the *Science on the Fly!* curriculum, students, under the guidance of their teachers or other mentors, will design and implement their own Environmental Service Learning Project (ESLP). Through this independent project, participants acquire valuable experience in planning and conducting a study or task; connect and apply their academic skills to real-life situations; develop a range of stewardship and community skills; and contribute to their communities and to environmental conservation by addressing an environmental concern that affects their local area. The ESLP would also qualify for student credit as a senior or independent study project.

Teachers can evaluate their students’ progress of their ESLP through periodic interim reports, presentations to the class, or the actual results of the project (e.g.: working with local policymakers to expand the recycling system in their school or town, identifying the sources of local pollutants and working with the polluters to decrease the cause). At the end of the school year, students could conduct a ESLP “recital” for the school, parents, and their classmates, in which they present (via posters, slide shows, field trips, etc) a summary of their ESLP and its results.

**SERVICE LEARNING:**

Service learning is an opportunity for participants, typically college or high-school students, to develop valuable teamwork, community involvement, leadership, and citizenship skills, and to enhance their communities through their contributions. Students expand upon their academic knowledge by engaging in critical thinking and problem-solving about their specific project and community challenges. In service learning, students’ social and emotional growth develop along with their academic and cognitive learning. The experiences obtained through service-learning are personally meaningful to the participants because they actively contribute to the projects and observe real results of their work in relation to community improvement. Examples of service learning projects include teaching senior citizens how to use computers, and educating peers about health and relationship issues.

Below are resources for educators to obtain more information about service learning, and to investigate service learning opportunities for their students. *Note that the list is not comprehensive, as new resources are constantly available, nor is it an endorsement of any specific project or organization.*

- **Learn and Serve America**
  - [www.learnandserve.org](http://www.learnandserv.org)
  - Learn and Serve America provides students with service-learning opportunities throughout the United States, enabling them to make meaningful contributions to their communities while enhancing essential academic and civic skills.
Learn and Serve: America's National Service Learning Clearinghouse
  - A valuable comprehensive resource about service learning that includes a history of service learning in the United States and characteristics of service learning. A broad range of ideas and curricular examples for all grade levels are provided, as are fact sheets, bibliographies, and links to other resources. The Service-Learning Research Capacity Hub is also an excellent resource for educators and students interested in participating in service learning research projects, including information on known and emerging scholars, and resources for conducting and publishing research, disseminating information, and securing external funding.

National Service-Learning Partnership
- [www.service-learningpartnership.org/site/PageServer](http://www.service-learningpartnership.org/site/PageServer)
  - The Partnership is a national network dedicated to promoting service-learning as an essential component of all students’ academic and civic preparation. Members are encouraged to share resources, organize change, and sponsor innovation among participants in service-learning projects.

National Youth Leadership Council
- [www.nylc.org](http://www.nylc.org)
  - The National Youth Leadership Council links youth, educators, and communities through service-learning to better define the roles of young people in society.

Youth Service America
- [www.ysa.org](http://www.ysa.org)
  - Youth Service America is an international nonprofit resource center that works to improve communities in more than 100 countries by increasing the number and diversity of young people, ages 5-25, serving in essential positions.

ENVIRONMENTAL SERVICE LEARNING:
Environmental service learning provides opportunities for participants to care for or improve the environment through community service. By conducting an ESLP, students not only achieve the skills and benefits from service learning, but they also contribute in a significant way to enhancing the environment in, and potentially beyond, their local communities. Additionally, many environmental service learning programs provide training opportunities and resources for making connections with students from other cultures and/or countries.

An example of an environmental service learning project is identifying air or water pollutants in the local area, determining their source(s), then collaborating with the source and other organizations to implement improved pollution controls. Based on their involvement in environmental community service, many students have developed highly effective organizations, such as the "Young Activists Organizing as Today’s Leaders", which have been instrumental in addressing a serious conservation concern in their local community.
Below are resources for educators to acquire additional information about environmental service learning, and to explore opportunities and programs for their students. *Note that the list is not comprehensive, as new resources are constantly available, nor is it an endorsement of any specific project or organization.*

- **Earth Force**
  - [www.earthforce.org](http://www.earthforce.org)
  - A national organization, Earth Force focuses on schools, teachers, and 10-14 year-old students to actively engage them as active citizens who work to improve the environment and their communities, with potential to become leaders in environmental issues. The website provides tools and curriculum resources for teachers, contact information for Earth Force’s local offices, and information about its programs and opportunities, including their national Youth Advisory Board.

- **Earth Force: Global Rivers Environmental Education Network**
  - [www.earthforce.org/section/programs/green](http://www.earthforce.org/section/programs/green)
  - The GREEN program offers middle and high school students opportunities to develop valuable skills, including critical thinking, teamwork, problem solving and decision making, while being actively involved in their communities to create lasting solutions for water quality issues. Through their curriculum, Protecting Our Watersheds, staff, and local partners, GREEN provides educators with access to a network of national and community support, online resources, technical manuals, activity guides, and water quality monitoring equipment to enable them to guide students in developing and implementing a project to address a local water quality concern.

- **Earth Force After School**
  - [www.earthforce.org/section/programs/afterschool](http://www.earthforce.org/section/programs/afterschool)
  - Complementing skills learned in the classroom, Earth Force After School provides students with fun and enriching experiences exploring the environment and collaborating with community leaders to improve local areas. Educators mentor students with the assistance of a self-contained kit that contains step-by-step instructions and activities for developing a community action problem-solving project.

- **Environmental Service Learning Definitions**
  - Definitions, resources, and curricula information about environmental service learning.

- **Environmental Service Learning Initiative**
  - [www.eslisf.org](http://www.eslisf.org)
  - A partnership of the Department of Children Youth and their Families, San Francisco Unified School District, Community Education Services, and Global Exchange, the Environmental Service Learning Initiative of San Francisco provides essential environmental education to San Francisco high school students through community service learning projects. Academic standards are integrated with a holistic understanding of the environment and environmental justice to inspire San Francisco students and teachers to develop and implement socio-environmental action projects in their local communities.
Green Works!
- www.plt.org/greenworks/greenworksguide.pdf
  - The Green Works! guide, developed by Project Learning Tree, provides educators with resources for involving their students in environmental service-learning projects, including classroom activities, ideas for designing and conducting a successful project, and project examples. Ideas for establishing collaborations between educators and local businesses, nonprofits, and other community organizations are also provided.

National Environmental Education Week - Resources - Environmental Service Learning
- www.eeweek.org/resources/service_learning
  - This website provides additional links to a variety of service and environmental-service learning resources.

National Wildlife Federation Conservation Action Guides
- http://online.nwf.org/site/PageServer?pagename=Youth_service_download
  - The guides provide a wide range of good ideas for youth service projects, including such topics as climate change, connecting people with nature, and healthy habitats.

United Nations Environment Programme – Tunza Youth Network
- www.unep.org/tunza
  - Through the Tunza Youth Network, the United Nations Environment Programme provides university and high school students, as well as younger children, with information and tools on how to address environmental concerns and conserve natural resources in their communities. Participation in the Tunza Youth Network provides opportunities for interacting and sharing information with other people and students from all over the world, and to learn more about the earth, conservation concerns, and behaving in an environmentally responsible manner.

Resource Center for Environmental Service Learning Programs
- www.nationalserviceresources.org/node/17138
  - The Corporation for National and Community Service provides opportunities for Americans to serve their communities and the nation through the Senior Corps, AmeriCorps, VISTA, NCCC, and Learn and Serve America. Participants collaborate with national and community nonprofit organizations, faith-based groups, schools, and local agencies to address community needs in a variety of areas, including education, the environment, and public safety.
  - The Resource Center for Environmental Service Learning Programs is the national service hub for:
    - Sharing information about training, technical assistance, innovations, and effective practices among the Corporation's programs.
    - Connecting potential grantees to relevant grant opportunities and resources.
    - Providing technical assistance to any organization that uses volunteers to enhance communities.
    - Providing online training tools and publications; an events calendar; the Effective Practices Collection; and a library of printed publications, videos, and other media for loan to Corporation grantees.
- **Roots and Shoots: The Power of Youth is Global**
  - [www.rootsandshoots.org](http://www.rootsandshoots.org)
  - The Roots & Shoots program, founded by Dr. Jane Goodall, connects youth in almost 100 countries who wish to implement successful community service projects, as well as participate in special events and global campaigns. Projects focus on wildlife, the environment, and people-centered programming.

- **Science and Civics: Sustaining Wildlife**
  - [www.projectwild.org/ScienceandCivics.htm](http://www.projectwild.org/ScienceandCivics.htm)
  - The *Science and Civics: Sustaining Wildlife Curriculum Guide* for grades 9-12 contains wildlife education activities and suggestions for implementing environmental service-learning projects. The Guide is a great instructional resource for educators to involve students in hands-on activities that promote problem-solving and decision-making skills concerning people, wildlife, and their shared habitat in the community. The curriculum is composed of four elements:
    1) **Awareness**: increases student understanding of human impacts to habitat quality and quantity;
    2) **Participatory Democracy**: develops government associated principles; compatible with government and civics units of social studies courses;
    3) **Habitat Exploration**: studies biotic and abiotic characteristics of a site; suitable for ecology and environmental science units of science courses; and
    4) **Taking Action**: guides students in developing, executing, and communicating projects to enhance a particular location or address a specific environmental concern.

- **Sierra Student Coalition**
  - [ssc.sierraclub.org/index.html](http://ssc.sierraclub.org/index.html)
  - The Sierra Student Coalition is the “student-run arm of the Sierra Club” involves high school and college students in national environmental campaigns and provides them with support, training, and resources for implementing conservation on local and national scales.

- **Student Environmental Action Coalition (SEAC)**
  - [www.seac.org](http://www.seac.org)
  - A national network of students and campus environmental groups which champions environmental justice campaigns at local and national levels.

- **Teens for Planet Earth**
  - [www.teensforplanetearth.org](http://www.teensforplanetearth.org)
  - Developed by the Wildlife Conservation Society, Teens for Planet Earth provides valuable resources for designing and implementing a successful environmental service-learning project, including the "Choosing a Conservation Project" guide and the "Building an Action Plan" guide. The social networking site enables participants to connect with other teens about conservation and their individual projects.
The CorpsNetwork: Strengthening America through service and conservation

- www.corpsnetwork.org
- Corps participants enhance communities and the environment through such programs as the Civic Justice Corps, Public Lands Corps, Clean Energy Service Corps, and Corps Respond. Through national service, Corps members acquire lifelong skills, including work readiness, educational advancement, civic engagement, and the ability to make responsible choices. Service and Conservation Corps conduct a vast array of conservation, infrastructure improvement, and human service projects, such as improvement and preservation of public lands and national parks; essential energy conservation services; restoration of natural habitat; creation of urban parks and gardens; disaster preparation; and recovery to under-resourced communities.

Recognition:

- Earth Island Institute’s New Leaders Initiative
  - www.broweryouthawards.org
  - The New Leaders Initiative (NLI) enhances the profile of emerging environmental leaders in North America by recognizing their achievements through the Brower Youth Awards, in memory of David Brower, the renowned environmentalist and community activist. Exceptional leaders are awarded with a cash prize, a high-energy week of activities, and ongoing leadership support, including skills, resources, and relationships to conduct successful campaigns and projects. Additionally, NLI provides rising young leaders with mentoring and project sponsorship opportunities.

- Teens for Planet Earth
  - www.teensforplanetearth.org
  - Teens for Planet Earth provides Service Awards to recognize students for exceptional environmental service-learning projects.
STEPS TO CONDUCTING AN ENVIRONMENTAL SERVICE LEARNING PROJECT

1. Identify an environmental issue or conservation concern you are interested in.

2. Conduct research (e.g.: interviews, web search, contact local officials…) to determine the history of this issue in your local community, including:
   - The cause or source of the problem.
   - The impact of the problem on the local environment, people, or wildlife.
   - What, if anything, has been done in your local community to address this issue.

3. Brainstorm with others (teachers, family, friends, mentors, community officials, environmental organizations…) on ideas that can be done to solve or improve the problem.

4. Choose one idea you would like to implement, and state the goal of your project clearly.

5. Determine what activities will lead to your goal.

6. Identify and obtain the resources you will need to conduct your activities and make your project a reality.
   - Materials or equipment:
     ○ Supply sources for equipment or materials.
   - Staffing/partnership:
     ○ Identify the number and expertise of the people needed to implement the project.
     ○ Identify potential collaborators in the community, school, or in local environmental organizations.
   - Funding:
     ○ Will you need funding to conduct your project and its associated outreach?
     ○ Identify potential sources of funding – e.g.: local businesses, foundations for grants…
   - Outreach:
     ○ How will you publicize your project and its results? Outreach will enable you to inform others of the issue you are addressing, and potentially involve them in your cause.

7. Establish a realistic timeline to conduct your activities and associated tasks (e.g.: fundraising, outreach…).

8. Conduct the activities with your partners and collaborating organizations.

9. Document and record your progress and results with notes, measurements, photographs…

10. Summarize the results of your project through a slide presentation, report, fact sheet, press release, or other method.

11. Present the results of your project to interested parties, such as your school or classmates, community leaders, or local environmental organizations.
## ENVIRONMENTAL SERVICE LEARNING PROJECT SUMMARY

<table>
<thead>
<tr>
<th>TASK</th>
<th>RECORD YOUR ANSWERS BELOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe the local environmental conservation issue you identified</td>
<td></td>
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<tr>
<td>History of problem in local community</td>
<td></td>
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<tr>
<td>Goal of your project</td>
<td></td>
</tr>
<tr>
<td>Resources needed to conduct project:</td>
<td></td>
</tr>
<tr>
<td>- Materials and equipment</td>
<td></td>
</tr>
<tr>
<td>- Partners</td>
<td></td>
</tr>
<tr>
<td>- Funding</td>
<td></td>
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<tr>
<td>- Outreach</td>
<td></td>
</tr>
<tr>
<td>Timeline of your project</td>
<td></td>
</tr>
<tr>
<td>Activities conducted to achieve goal</td>
<td></td>
</tr>
<tr>
<td>Results of your project</td>
<td></td>
</tr>
<tr>
<td>Community response to your project</td>
<td></td>
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</tbody>
</table>

*Please send a copy of your project summary to BRI’s Adirondack Center for Loon Conservation at adkloon@briloon.org, so your results and project can be highlighted on our website, www.briloon.org!*
SCIENCE ON THE FLY! UNIT #2 – MERCURY AND ACID RAIN

TEACHER EVALUATION

Thank you for participating in the Mercury and Acid Rain Unit of Science on the Fly! Your feedback is very important to us. We also greatly appreciate receiving copies of your students’ work, in particular, a summary of the Environmental Service Learning Projects conducted by your students. If you have examples to send to us, please include them with the evaluation forms.

Teacher: __________________________ Grade: __________________________
School: __________________________ Date: __________________________
Street: __________________________ Phone: __________________________
City, State, Zip: __________________________ E-Mail: __________________________

Please place an “A” or “B” in the following categories regarding the applicability of the curriculum components to (A) the interests of the students AND (B) the scientific objectives of the educator:

<table>
<thead>
<tr>
<th>CURRICULUM COMPONENT</th>
<th>POOR</th>
<th>FAIR</th>
<th>GOOD</th>
<th>GREAT</th>
<th>EXCELLENT!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science on the Fly! Website</td>
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<tr>
<td>Resources for Classroom Activities</td>
<td></td>
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<tr>
<td>Resources for conducting an Environmental Service Learning Project</td>
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</tbody>
</table>

Please Check the Following:  

- Teacher’s Manual served as a useful reference.
- Education materials were accompanied with adequate instruction from BRI’s Adirondack Center for Loon Conservation.
- Scientific objectives and concepts were clearly outlined and presented in the curriculum.
- Course content was appropriate to age level and learning capabilities of students.
- The Science on the Fly! website enabled students to acquire and utilize their knowledge of common loons; the causes, chemistry, and ecological impacts of mercury pollution and acid deposition; efforts to decrease airborne pollutants; and opportunities to contribute to environmental conservation in their own homes and communities.
- The resources for classroom activities provided opportunities for students to gain direct experience about the chemistry and impacts of mercury pollution and acid deposition, and energy conservation.
- Curriculum fulfilled appropriate national and state science learning and teaching standards.
- Content, classroom activities, and the Environmental Service Learning Project built upon previous knowledge base of students.
- Information exposed students to the connections between human activities/impacts and regional environmental conservation issues.
- Presentation of material encouraged students to assess and evaluate the effects of their actions on the environment and its wild inhabitants.
- Curriculum promoted creative thinking and skills to address environmental conservation issues.
Please provide the following comments based on your overall impression of Science on the Fly!:

1. How much do you think your students benefited from the Science on the Fly! curriculum (Circle one)?

<table>
<thead>
<tr>
<th>NOT VERY MUCH</th>
<th>SOME</th>
<th>A GREAT DEAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>4</td>
<td>5</td>
<td></td>
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</tbody>
</table>

Please explain:

2. Does the Science on the Fly! curriculum contribute directly to your current curriculum and required course of study (Circle one)?

<table>
<thead>
<tr>
<th>LOOSE FIT</th>
<th>GOOD FIT</th>
<th>INVALUABLE DIRECT FIT</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>4</td>
<td>5</td>
<td></td>
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</tbody>
</table>

Please explain:

3. What did you like best about Science on the Fly!?

4. What did you like least about Science on the Fly!?

5. How could Science on the Fly! be improved?

6. Describe the classroom activities and the Environmental Service Learning Projects conducted by your students (use additional paper if needed, and please include samples of their work).

7. Comments, concerns, ideas...

Please contact BRI’s Adirondack Center for Loon Conservation at 888-749-5666x145 or adkloon@briloon.org with any additional questions or suggestions.

**THANK YOU FOR YOUR FEEDBACK!**

**PLEASE RETURN FORM TO:**

BRI’s Adirondack Center for Loon Conservation  
PO Box 195  
Ray Brook, NY 12977
SCIENCE ON THE FLY! UNIT #2 – MERCURY AND ACID RAIN
STUDENT EVALUATION

The opinions and ideas of the students are very important to us. Teachers, please survey your students by reading aloud the following, and asking the students to record their answers on a sheet of paper that will be submitted to you. Then please tally the student responses and return this evaluation form as a summary of the entire class’s opinions.

THANK YOU ALL FOR PARTICIPATING IN SCIENCE ON THE FLY!

Please refer to the following Science on the Fly! curriculum components, and record the number of students that responded in each category:

<table>
<thead>
<tr>
<th>CURRICULUM COMPONENT</th>
<th>POOR</th>
<th>FAIR</th>
<th>GOOD</th>
<th>GREAT</th>
<th>EXCELLENT!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science on the Fly! Website</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classroom Activities about mercury, acid rain, and energy conservation</td>
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<td></td>
<td></td>
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<tr>
<td>Environmental Service Learning Project</td>
<td></td>
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</tbody>
</table>

Please ask your students to choose which component of the Science on the Fly! curriculum they found most enjoyable and why. Record the number of students that responded in each category.

<table>
<thead>
<tr>
<th>CURRICULUM COMPONENT</th>
<th>LEAST ENJOYABLE</th>
<th>MOST ENJOYABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science on the Fly! Website</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classroom Activities about mercury, acid rain, and energy conservation</td>
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<td></td>
</tr>
<tr>
<td>Environmental Service Learning Project</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please provide 2-3 comments from your students about the aspects of the Science on the Fly! curriculum components they enjoyed or did not enjoy:

**SCIENCE ON THE FLY! WEBSITE:**

Students enjoyed:

Students did not enjoy:

**CLASSROOM ACTIVITIES ABOUT MERCURY, ACID RAIN, AND ENERGY CONSERVATION:**

Students enjoyed:

Students did not enjoy:

**ENVIRONMENTAL SERVICE LEARNING PROJECT:**

Students enjoyed:

Students did not enjoy:
Please read the following to your students, and provide comments from the students regarding their overall opinion of Science on the Fly!:

1. Was there anything the students would like to see or do that was not in the curriculum? Please explain:

2. How much of Science on the Fly! was new material for the students? (Please record the number of students in each category)

<table>
<thead>
<tr>
<th>IT WAS A REVIEW</th>
<th>SOME WAS NEW</th>
<th>IT WAS ALL NEW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 =</td>
<td>2 =</td>
<td>3 =</td>
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<tr>
<td>4 =</td>
<td>5 =</td>
<td></td>
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</tbody>
</table>

3. How interesting was Science on the Fly! to the students? (Please record the number of students in each category)

<table>
<thead>
<tr>
<th>BORING</th>
<th>SOMEWHAT INTERESTING</th>
<th>VERY INTERESTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 =</td>
<td>2 =</td>
<td>3 =</td>
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<tr>
<td>4 =</td>
<td>5 =</td>
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</tr>
</tbody>
</table>

4. What were three of the most interesting things the students learned?
   a. 
   b. 
   c. 

5. Was there anything that was confusing or unclear in the program? Please explain:

6. Please include any additional student comments below or on the back of this page.

THANK YOU FOR YOUR SUGGESTIONS!

TEACHERS, PLEASE RETURN FORM TO:

BRI’s Adirondack Center for Loon Conservation
PO Box 195
Ray Brook, NY 12977
APPENDIX #1: TEACHER LOG IN TO THE SCIENCE ON THE FLY! WEBSITE

The Science on the Fly! website, www.scienceonthefly.org, is designed to enable teachers to examine the work and follow the progress of individual students as they advance through the website.

TEACHER LOG-IN:
- Navigate to www.scienceonthefly.org
- Click on Teachers to “Log in” or “Create a New Account” for your classroom.
- Follow the instructions on the Teachers page to set up an account or to log-in to an existing account. If you are setting up a new account, you will need to create or provide a user name, password and e-mail address. Verification of registration will be sent to the e-mail address that is submitted.
- To Create a New Class, the class name and optional description of the class will be entered.
- The teacher will be issued a Class ID number. Please provide this Class ID number to your students so that they can log-in from any computer.
- When a class is created, the teacher will click on Add a Student and enter the user name and password for each student whose work will be monitored.
- The information for each student, including user name, password, and actions will be recorded into a table on the Class Information page.
- After creating a class, assign one or both of the available questions to that class. This generates the drop down list for students to choose which unit of Science on the Fly! they will explore.
- The Action column has three commands that allows the teacher to:
  - Edit – User information and password can be changed for each student
  - Status – Allows teacher to determine what steps have been completed by the student
  - Delete – Allows teacher to delete a student
- Click Logout when completed and invite your students to discover Science on the Fly!

Please Disable Pop-Up Blockers: The Science on the Fly! website has “pop-up” links, thus teachers may need to disable pop-up blockers on school computers so that students can view website links.

STUDENT LOG-IN:
- Instruct your students to log on to www.scienceonthefly.org through the “Class Assignment” button.
  - Students will need to provide their assigned user name, password, and Class ID number to enter the website.
- Students should choose the Science on the Fly! unit, “Loon Migration” or “Mercury and Acid Rain,” assigned to them by their teacher.
- Once a student has logged on and completed a section of the website, the teacher is able to log on through the “Teachers” button and review the student’s work.
- Alternatively, students (or the general public) can log on to www.scienceonthefly.org through the “Just for Fun” button if their work will not be reviewed, and they would like to see how the website works. They can then choose the “Loon Migration” unit or the “Mercury and Acid Rain” unit.
APPENDIX #2: PHOTOS FOR LOONS UP CLOSE! ACTIVITY

The photographs below depict physical characteristics of loons that are essential specializations and adaptations for living in an aquatic environment. The students should initially examine the photos without the accompanying text to draw their illustrations and field notes about loon specializations.

**Top:** Legs are positioned far back on the body, and feet are large, even in young loons.

**Bottom:** Loon legs are flattened, decreasing resistance as a loon swims through the water.
**Top:** In all stages of their life, loon underbodies are white, in contrast to their upper bodies, which are dark. Such coloration is good camouflage from predators swimming below or flying above.

**Bottom:** Loons are capable of powerful flight once they get airborne.
Top: Loon beaks are pointed and powerful, and their eyes are red in the breeding plumage.

Bottom: Loons change coloration in the winter months to a gray, drab plumage.
**Top:** Loon bodies are streamlined, enabling them to swim through the water with minimal resistance.

**Bottom:** Loons are very large birds. Male Adirondack loons typically weigh more than 12 pounds (5500gms).
APPENDIX #3: POND EQUIPMENT MADE EASY

SUGGESTED MATERIALS LIST:

For Collection of Specimens:
- Plastic buckets or containers to carry supplies and water samples
- Plastic bags to transport any larger organisms
- Rubber boots or waders
- Field guide for aquatic plants and animals
- Pond dip net or collection net
- Field notebook & pencil
- Tweezers or forceps
- Underwater viewer
- Hand lens or magnifiers
- Plankton net (mesh size should be approximately 1 mm)

For Classroom Observations:
- Aquarium or small children’s swimming pool
- Water pump
- Microscope & slides
- Hand lens or magnifiers
- Underwater Viewer
- Observation Pan or Basins
- Field guide
- Field notebook or journal
- Thermometer to record water temperature
- pH kit or water quality kit to measure acidity and nutrients in pond water

POND EQUIPMENT:
- Underwater viewer: Cut off the bottom of a coffee can, tin can, or tube (e.g.: PVC pipe), and cover with plastic wrap. Use a large rubber band to fasten the plastic wrap.
- Collection net for large organisms: Use electrician’s or duct tape to secure a kitchen strainer to the end of a broom handle.
- Observation Pan: Cut off the bottom of a large plastic, white milk bottle and add pond water. The light colored bottom allows darker organisms to be easily observed. The top of the bottle, with the lid, can be used as a collecting pail.

POND SET-UP:
- Place aquarium or pool on a level surface in a location away from high traffic areas, such as doorways. Do not place in locations with direct sunlight or in close proximity to heating or air-conditioning vents.
- Place a water pump in the aquarium or pool to keep the aquarium supplied with oxygen and to keep the water circulating.
- Place the pond sediment or gravel in the bottom of the aquarium or pool. Add a few decaying leaves and rooted or floating plants.
- Slowly add the pond water until the sediment is covered and allow the aquarium to sit for a day. Carefully add the rest of the pond water by pouring through a strainer to avoid disturbing the plants or sediment.
GUIDELINES FOR COLLECTION OF AQUATIC ANIMALS:
Insects, tadpoles or other large organisms can be collected and added to the artificial pond habitat. However, the following guidelines should be adhered to:

- **State or federally PROTECTED SPECIES SHOULD NOT BE COLLECTED.** All animals (e.g.: insects, amphibians, reptiles...) should be correctly identified prior to collection to ensure that no protected species are accidentally collected.
  - It is recommended that turtles and other reptiles NOT BE COLLECTED as their diets and husbandry requirements are very specialized, and they may carry Salmonella.
- **It is highly recommended that all animals be returned to the site of collection after 1-2 weeks of observation in the captive environment.**
- If fish are added to the aquarium, use one gallon of water per one inch of fish.
- Tadpoles may require a floating platform as they develop into frogs.
- Plant-eating animals, such as fish, snails, and tadpoles, will consume plants within the aquarium, therefore it is suggested that live aquatic plants be added to the artificial pond habitat to supplement their diet.
- One or more students should be assigned to researching the diet and husbandry requirements of each species collected, and responsible for providing the proper care and diet while the animals are in captivity.

CONTROL OF ALGAE:
- Reduce the algae’s food source by adding aquatic plants, which will absorb food faster than the algae.
- Reduce the amount of light reaching the algae by moving the aquarium to a different location, adding plants with floating leaves or covering the side of the aquarium closest to the window.
- Avoid the accumulation of waste on the bottom of the aquarium.
APPENDIX #4: POND ACTIVITY SAMPLE INQUIRIES AND PROJECT TOPICS

SAMPLE INQUIRIES FOR ARTIFICIAL POND HABITAT:

- What are the three most important factors in sustaining life in a pond or aquarium?
- What is the pH in the aquarium or pool? How would a more acidic or basic environment affect the organisms in the pond?
- What are the different types of plants found in the pond community? What is the effect of light on plant life in the aquarium?
- What are the differences in microscopic life found between different samples of pond water?
- What are the differences between Zooplankton and Phytoplankton? What do these organisms need to successfully survive?
- How long does it take for a tadpole to turn into a frog, and what are the physical changes the tadpole goes through during its transformation into a frog? Does this vary by species?
- What kinds of macro-invertebrates exist in the pond water and what are some of their unique characteristics?
- Why does algae grow? Do light and temperature have an effect on the growth of algae and how do they affect the other organisms in the pond community?
- Do the larger organisms (e.g.: snails, fish, reptiles, amphibians) establish particular locations or territories in the aquarium?
- What are the different habitats found in a pond community?

SAMPLE INQUIRIES FOR NATURAL POND HABITAT:

- What animal species utilize the natural pond habitat?
  - What is their role in the aquatic ecosystem?
- If the pond is important for migratory birds, what other types of habitat do they live in at other times of the year? Why is this pond an important stopover place during their migration or why did they come here to breed or winter?
- What factors (e.g.: invasive plants, pollutants, shoreline development...) are affecting the ecology of this pond and the organisms living in it?
  - Are these problems similar or different from what is observed in the artificial pond habitat?
  - What can be done to improve the site to make it a better habitat?
  - What is already being done to protect or improve this aquatic community?
- How can students become involved in conservation of the aquatic and terrestrial habitats around them?

PROJECT TOPICS:

- Describe a pond and the different types of pond communities.
- Illustrate a typical food chain in a pond.
- Describe the ecological succession in a pond community.
- List and describe some of the limiting factors in the pond.
- Document the hydrologic cycle.
- Conduct an inventory of the plants and animals living in the pond.
- Identify what species are federally or state protected, and those that can be legally collected.
- Implement a project to improve or protect a nearby natural pond community.

*Adapted from Yale – New Haven Institute – Pond Ecology Curriculum by Joe Lewis, www.cis.yale.edu/ynhti/curriculum/units/1992/5/92.05.07.x.html*
APPENDIX #5: POND STUDY VOCABULARY LIST AND SUGGESTED WEBSITES

- **Benthic**: Relating to or occurring at the bottom of a body of water.
- **Chlorophyll**: The green photosynthetic chemical in plant leaves that helps absorb and trap sunlight.
- **Consumer**: An organism requiring complex organic compounds for food, which it obtains by preying on other organisms or by eating particles of organic matter.
- **Decomposer**: An organism (e.g.: many bacteria and fungi) that feeds on and breaks down dead organic material, thus returning nutrients to ecological cycles.
- **Detritus**: Loose material (e.g.: rock fragments or organic particles) that result from disintegration or decay or organic and inorganic matter.
- **Ecosystem**: An area that includes both living and nonliving components.
- **Emergents**: Aquatic plants that grow above the water.
- **Floating Plants**: Aquatic plants whose leaves float on the surface of the water.
- **Food Chain**: The sequence in which one organism consumes another as a source of energy.
- **Habitat**: The place or type of site where a plant or animal naturally or normally lives and grows.
- **Inlet**: A stream flowing into a lake or pond.
- **Insect**: A six-legged creature with three body parts, an exoskeleton, and an antenna. Insects grow and develop through metamorphosis.
- **Invertebrate**: An animal lacking a spinal column.
- **Littoral Zone**: The layer in a body of water where the water depth is shallow, enabling light to penetrate to the bottom of the pond or lake, so rooted plants can grow.
- **Metamorphosis**: A marked and abrupt change after birth or hatching in the form or structure of an animal (such as a butterfly or frog).
- **Outlet**: A stream flowing out of a lake or pond.
- **Photosynthesis**: The process chlorophyll-containing plants use to convert water, sunlight and carbon dioxide into a simple sugar (carbohydrate).
- **Plankton**: A passively floating or weakly swimming animal or plant living in a body of water.
- **Producer**: An organism (such as a green plant) which produces its own organic compounds from simple precursors (e.g.: carbon dioxide and inorganic nitrogen). Many producers are food sources for other organisms.
- **Protozoa**: Single-celled microorganisms living in lakes, oceans, rivers, and ponds.
Respiration: The physical and chemical processes by which an organism supplies its cells and tissues with the oxygen needed for metabolism and relieves them of the carbon dioxide formed in energy-producing reactions.

Submergents: A group of aquatic plants that are completely submerged and grow under the water’s surface.

Watershed: A region or area drained by a water body.


SUGGESTED WEB SITES ABOUT POND ECOLOGY:

- **Aquatic Critters:** [http://mbgnet.mobot.org/fresh/slide/intro.htm](http://mbgnet.mobot.org/fresh/slide/intro.htm) This website contains identification information about commonly observed plants, amphibians, reptiles, fish, insects, and macro-invertebrates that are found in pond communities.

- **Missouri Botanical Garden:** [http://mbgnet.mobot.org/](http://mbgnet.mobot.org/) This website provides a wealth of information about the biomes of the world, and freshwater and marine ecosystems.

- **A Virtual Pond Dip:** [www.microscopy-uk.org.uk/index.html](http://www.microscopy-uk.org.uk/index.html) This site allows viewers to access information relating to microorganisms found in pond water.

- **Yale New Haven Teachers Institute – Pond Ecology:** [www.cis.yale.edu/ynhti/curriculum/units/1992/5/92.05.07.x.html](http://www.cis.yale.edu/ynhti/curriculum/units/1992/5/92.05.07.x.html). This reference is an excellent resource for both teachers and students. Teachers can obtain information relating to the scientific process, the dynamics of freshwater pond communities, and examples of experiment design. Students can familiarize themselves with the hydrologic cycle and the basics of pond ecology by focusing on Section III and Section IV.
APPENDIX #6: MERCURY AND ACID RAIN UNIT VOCABULARY LIST

- **Anaerobic**: Able to live without the presence of oxygen.
- **Aquatic**: Related to water.
- **Bacteria**: One celled organisms that reproduce through division.
- **Bedrock**: The underlying solid rock located beneath soil layers.
- **Bioaccumulate**: To build up in a biological system – usually refers to the accumulation of toxic substances in the tissues of plants and animals.
- **Biodiversity**: The diversity of plant and animal life in a specific area.
- **Biota**: Living beings, including mammals, insects, birds, invertebrates, fish.
- **Buffering Capacity**: The ability of a particular area, such as a lake or pond, to resist the detrimental impacts of acid rain.
- **Cap and Trade System**: A permit system used to reduce pollution emissions in the environment. A cap, or limit, is placed on the amount of pollution that is able to be released and permits are issued allowing certain amounts of the pollution to be released. These permits are able to be traded, but may result in hotspot areas located on the landscape.
- **Cation**: A positively charged ion.
- **Downwind**: Located in the direction that the wind is blowing.
- **Dry Deposition**: The deposition of mercury or acids that attach to small atmospheric particles and slowly fall or settle out of the atmosphere onto the surrounding landscape.
- **Ecosystem**: The relationship between a community of organisms and its surrounding environment.
- **Element**: A substance that cannot be broken into simpler parts.
- **Emissions**: To release a substance into water or the atmosphere.
- **Environmental Protection Agency**: A U.S. government agency designed to protect human health and the environment.
- **Episodic Acidification**: A rapid increase in the acidification of a lake or stream. This phenomenon usually occurs seasonally, particularly during snow melt in the spring.
- **Geothermal**: Heat released from the interior of the Earth.
- **Global Cycle**: The process by which mercury cycles through the environment as a result of natural and human processes.
- **Guano**: The excrement of seabirds or bats.
- **Hotspot**: A location where pollution levels exceed the recommended thresholds that are considered safe for humans and wildlife.
- **Hydropower**: Using water to generate electricity.
- **Incinerator**: A large furnace for burning materials.
- **Industrialization**: A time in history when factories and machines were being rapidly developed and put into use.
- **Inorganic**: Non-living compounds that do not contain carbon.
- **Metabolic**: Chemical activities that convert food into energy needed to sustain life.
- **Methylation**: The conversion of mercury to methylmercury through the addition of a methyl group (CH3). This is often carried out by sulfate-reducing bacteria existing in anaerobic (low oxygen) environments.
- **Methylmercury**: A highly toxic form of mercury, produced through methylation, that is often found in the tissues of animals.
- **Molt**: The process of shedding old feathers that are replaced by new feathers.
- **Neurotoxin**: A toxic substance that damages nerve tissues and affects behavior.
- **Neutralize**: A substance that is neither acidic nor basic. A neutral substance has a pH of 7.0.
- ** Organic**: Chemical compounds that contain carbon.
- **Oxidize**: A chemical reaction that includes oxygen.
- **Particulate Matter**: Very small particles of liquid or solid matter that are considered atmospheric pollutants.
- **Piscivore**: A fish-eating predator.
- **Pollutant**: A substance, such as certain chemicals or waste products, that renders the air, soil, water, or other natural resource harmful or unsuitable for a specific purpose or for animals or humans to live in.
- **Prevailing Wind**: Wind direction.
- **Spawn**: Reproduction in fish - the female fish lay eggs (often in large masses) and the male fish cover the eggs with sperm (also called "milt"), which fertilizes the eggs.
- **Sulfate**: A derivative of sulfuric acid.
- **Synergistically**: To work together.
- **Terrestrial**: Living or growing on land.
- **Topographical**: The natural and man-made features that exist on a landscape.
- **Toxic**: A poisonous or deadly substance.
- **Water Column**: All of the physical and chemical properties that exist between the top and bottom of a body of water.
- **Wet Deposition**: The deposition of atmospheric particles (such as mercury or acids) that bind with water molecules and settle out of the atmosphere onto the surrounding landscape through rain or snow, clouds, or fog.
- **Wetland**: An area that is typically saturated by water and can support specific types of vegetation adapted to those conditions.
- **Zooplankton**: Microscopic aquatic organisms that form the basis of the aquatic food chain.
APPENDIX #7: STUDENT ASSESSMENT RUBRIC

The table below enables the *Science on the Fly!* educator to assess skills students should utilize to progress through the *Science on the Fly!* curriculum.

<table>
<thead>
<tr>
<th>STUDENT PERFORMANCE</th>
<th>NEVER</th>
<th>RARELY</th>
<th>SOMETIMES</th>
<th>OFTEN</th>
<th>ALWAYS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstrates understanding of important scientific concepts based on curriculum components.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Demonstrates understanding of the fundamentals of the scientific process or energy conservation as shown in classroom activities and assignments.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Applies knowledge to solve problems.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Keeps thorough and accurate records of observations.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Demonstrates appropriate use of laboratory materials.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Logically collects and organizes data.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Draws logical conclusions from experiment or ESLP results.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Clearly communicates conclusions based on results.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Evaluates and compares results of investigations with similar experiments.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Utilizes prior knowledge to build upon concepts being learned.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Makes clear connections between various components of the curriculum.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Ability to work cooperatively with others.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Work is completed by assigned deadlines.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Overall quality of work and ability to meet curriculum objectives.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

*Adapted from Creative Teacher Press, www.creativeteacher.com*
APPENDIX #8: SCIENCE ON THE FLY! MEETS NEW YORK STATE LEARNING STANDARDS

The Science on the Fly! curriculum meets many New York State Learning Standards. Additional information about New York State Learning Standards is available at www.emsc.nysed.gov/nysatl/standards.html. Examples of New York State standards met by Science on the Fly! are listed below:

Standard #1: Analysis, Inquiry, and Design
Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.
1. The central purpose of scientific inquiry is to use a continual, creative process to develop explanations of natural phenomena.
2. Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations using conventional techniques and procedures, and often requiring considerable ingenuity.
3. The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena.

Standard #2: Information Systems
Students will assess, generate, process, and transfer information using appropriate technologies.
1. Information technology is used to retrieve, process, and communicate information and as a tool to enhance learning.
2. Knowledge of the impacts and limitations of information systems is essential to its effective and ethical use.
3. Information technology can have positive and negative impacts on society, depending upon how it is used.

Standard #3: Mathematics
Students will understand mathematics and become mathematically confident by communicating and reasoning mathematically, applying mathematics in real-world settings, and by solving problems through the integrated study of number systems, geometry, algebra, data analysis, probability, and trigonometry.
1. Students use mathematical reasoning to analyze mathematical situations, make conjectures, gather evidence, and construct an argument.
2. Students use number sense and numeration to develop an understanding of the multiple uses of numbers in the real world, the use of numbers to communicate mathematically, and the use of numbers in the development of mathematical ideas.
3. Students use mathematical operations and the relationships among them to understand mathematics.
4. Students use mathematical modeling/multiple representation to provide a means of presenting, interpreting, communicating, and connecting mathematical information and relationships.
5. Students use measurement in both metric and English measure to provide a major link between the abstractions of mathematics and the real world in order to describe and compare objects and data.
6. Students use ideas of uncertainty to illustrate that mathematics involves more than exactness when dealing with everyday situations.
7. Students use patterns and functions to develop mathematical power, appreciate the true beauty of mathematics, and construct generalizations that describe patterns simply and efficiently.

**Standard #4: Science**
Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment, and recognize the historical development of ideas in science.

1. Living beings are both similar to and different from each other and non-living objects.
2. Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.
3. Individual organisms and species change over time.
4. The continuity of life is perpetuated through reproduction and development.
APPENDIX #9: SCIENCE ON THE FLY! MEETS NATIONAL SCIENCE EDUCATION STANDARDS

The Science on the Fly! curriculum meets many National Science Education Learning and Teaching Standards. Additional information about National Science Education Standards is available at www.nsta.org/standards. Examples of standards met by Science on the Fly! are listed below:

Science as Inquiry
Students will develop the abilities necessary to engage in and understand scientific inquiry.
1. Students will identify questions that can be answered through scientific investigations using knowledge of scientific concepts as a means to guide their investigation.
2. Students will design and conduct a scientific investigation and develop skills related to observation, taking precise measurements and identifying and controlling variables.
3. Students will determine the appropriate tools and technology needed to gather, analyze, and interpret the information they are working with.
4. Students will develop descriptions, explanations, predictions, and models based on the evidence they have gathered through the course of the investigation.
5. Students will develop the ability to think critically about how evidence should be interpreted and to recognize and acknowledge alternative explanations or predictions.
6. Students should be able to effectively communicate their methods and results to others.
7. Students should recognize that mathematics is used in most aspects of scientific inquiry and is essential to answering questions about the natural world.

Physical Science
Students will develop an understanding of the properties and characteristics of matter and the transfer of energy between systems.
1. Students will examine characteristic properties, such as density and boiling point, and the principles associated with how substances react with other substances to form new substances containing different properties.
2. Students will be exposed to the concepts of energy transfer between systems and its association with heat, light, electricity, mechanical motion, and sound.

Life Science
Students will gain a basic understanding of the structure and function in living systems, reproduction and heredity, regulation and behavior, populations and ecosystems, and diversity and adaptation of organisms.
1. Students will gain awareness of the structure and function of cells, organs, tissues, organ systems, whole organisms, and ecosystems.
2. Students will learn that reproduction and heredity is a characteristic of all living systems and is essential for the perpetuation of life on earth.
3. Students will examine that all organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment in order to survive.
4. Students will be exposed to the principles that populations are comprised of individuals of a given species that occur together at the same time and place.
5. Students will develop an understanding of the diversity of organisms through biological evolution and the theory of adaptation as a means to enhance the survival and reproductive success of a particular species in a given environment.
Science and Technology
Students will investigate the abilities of technological design and the relationship between science and technology.
1. Students will acquire insight into the principle that technology is essential to science, because it provides instruments and techniques that enable observation and quantification of objects and variables that would not be observable in factors such as quantity, distance, location, size and speed.

Science in Personal and Social Perspectives
Students will begin to develop an understanding of the relationships between populations, resources and the environment. They will also assess the roles of natural hazards and the impacts of science and technology on society.
1. Students will examine the principles associated with overpopulation and the degradation of the surrounding environment due to the increased use of resources.
2. Students will be exposed to the impacts that natural hazards can have on wildlife and human habitat, in addition to the effects that human activities can have on accelerating natural changes through vectors such as resource acquisition, urban growth, and land use decisions.
3. Students will begin to understand the influence that scientific knowledge and procedures have on society's perception of themselves, others, and the environment.

History and Nature in Science
Students will gain awareness of science as a human endeavor and the basic nature of science.
1. Student will learn that science is a human endeavor that requires many different abilities and relies on basic human qualities such as reasoning, insight, energy, skill, and creativity.
2. Student will begin to understand that science inquiry is based on developing questions, using observations to investigate a hypothesis, and developing scientific ideas that are subject to change and improvement. While scientists may disagree about the explanations or interpretation of data, they realize that questioning, response to critique, and good communication are integral to the process of science.
APPENDIX #10: LOON MONITORING AND RESEARCH ORGANIZATIONS

Alaska Loon Watch
http://aknhp.uaa.alaska.edu/LoonWatch/index.htm

BioDiversity Research Institute
19 Flaggy Meadows Road
Gorham, ME 04038
(207) 839-7600
www.briloon.org

BRI’s Adirondack Center for Loon Conservation
P.O. Box 195, Ray Brook, NY 12977
(888) 749-5666 x 145
www.briloon.org/science-and-conservation/centers/adirondackloons.php

Canadian Lakes Loon Survey
Bird Studies Canada
P.O. Box 160
Port Rowan, Ontario
Canada, N0E 1M0
(888) 448-2473
www.bsc-eoc.org/cllsmain.html

The Maine Loon Protection Project
Maine Audubon Society
20 Gilsland Farm Road
Falmouth, ME 04105
(207) 781-2330
www.maineaudubon.org/conserve/loon/index.shtml

Loon Lake Loon Association
P.O. Box 75
Loon Lake, WA 99148
(509) 233-2145
www.loons.org

Loon Preservation Committee
Audubon Society of New Hampshire
P.O. Box 604
Moultonborough, NH 03254
(603) 476-5666
www.loon.org

Loon Watch, Sigurd Olson Environmental Institute
Northland College
Ashland, WI 54806
(715) 682-1220
www.northland.edu/sigurd-olson-environmental-institute-loon-watch.htm

Massachusetts Division of Fish and Wildlife, Natural Heritage & Endangered Species Program
One Rabbit Hill Rd.
Westboro, MA 01581
(508) 389-6300
www.mass.gov/dfwele/dfw/nhes/nhesp.htm

Michigan Loon Preservation Association
10181 Sheridan Rd.
Millington, MI 48746
www.michiganloons.org

Minnesota Loon Monitoring Program
500 Lafayette Road
St. Paul, MN 55155
888-646-6367
www.dnr.state.mn.us/eco/nongame/projects/mlmp_state.html

Montana Loon Society
P.O. Box 1131
Seeley Lake, MT 59868
www.montanaloons.org

Oikos Research Foundation
Dr. J.W. McIntyre, Director
8 Sherman Circle
Utica, NY 13501

USFWS Migratory Bird Mgmt.
1011 E. Tudor Rd. MS 201
Anchorage, AK 99503
(907) 786-3517
http://alaska.fws.gov/mbsp/mbm/loons/loons.htm
USGS Upper Midwest Environmental Sciences Center – Loon Migration
2630 Fanta Reed Road
La Crosse, Wisconsin 54603
(608) 783-6451
www.umesc.usgs.gov/terrestrial/migratory_birds/loons/migrations.html

Vermont Loon Recovery Project
Vermont Center for Ecostudies
PO Box 22,
Craftsbury, VT 05826
(802) 586-8064
www.vtecostudies.org/loons

APPENDIX #11: A SAMPLING OF LOON LITERATURE

LOON LEGENDS AND CHILDREN’S BOOKS ON LOONS:


LOON NATURAL HISTORY BOOKS AND LITERATURE:


